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*Some Observations*

*Concerning the Baroscope and Thermoscope, made and communicated by Doctor I. Wallis at Oxford, and Dr. I. Beale at Yeovil in Somerset, deliver'd here according to the several dates, when they were imparted.*

*Dr. Beale in those Letters of his dated Decemb. 18. Decemb. 29. 1669. and Januar. 3. 16<sup>69</sup>.*

**H**aving not look'd upon my Barometer a long time, I did by meer chance cast my Eye on it upon Munday last, Decem. 13. 1669. about one of the Clock p. m.; and just then I saw the Quicksilver higher, than I dare positively affirme that it was ever since I had it in my custody, *viz.* since May 28, 1664. It was compleatly and apparently above half an inch more than thirty inches high. I called younger men to examine it over and over very carefully, by a measure, taken exactly from the standard-foot of *London*, both in Brads and in Box. They measured it often from that time, which was Munday, and late in the night of that day; then on Tuesday morning early; oft-times in the day, and late at Night: also some part of Wednesday. In all which time, when it was lowest, it was (as I said at first) compleatly  $30\frac{1}{2}$  inches; sometimes manifestly higher to the eighth or tenth part of a inch.

For this Baroscope I have two Glass-canæs in one vessel of stagnant Quicksilver. They are of equal length, not fully two inches higher, than the Mercury ascended, and no Bolt-head to either of the Glasses. The one hath not been moved these two or three years, and hath a tincture of the Mercury on the empty top, as from the steams of the Mercury in some hot Summer; the other Glass was placed there about a year and an half agoe. This hath no tincture on the top. Both agreed in this Indication, as others affirme; but, to my Eye, in the latter Glass the Quicksilver seem'd to be something higher.

The Weather was at first discovery very bright and clear; a gentle frost, by the Suns heat melting. The Air was very silent, no wind stirring, and the curious Wind-vane noting, that the wind was directly in the *East* all the first day (Decemb. 13;) on

on *Decem.* 14. the wind had a short swing from the *North-west*, and hastened again toward the *East*, yet so as to be *North-East*. During this agitation, or change of Winds, the Mercury descended a little; and after, upon the settling of the wind, the Mercury ascended a little higher, than it had been the day before.

My House and Study, where I keep this Baroscope, is on the side of an Hill; on the higher side of this Country, as I guess near a level with the Head of a River; which River, running slowly, and falling into the *Severne-Sea* about 20. or 30. miles West-ward of *Bristol*, we cannot be very much above the level of the Sea.

My Thermoscope, standing close by my said Barometer, was at the just hight of ordinary dissolving Weather. In the following dayes it was colder. Whether the late Summer-drought, or what else, might incline this Winter-air to have more than ordinary Weight, or a stronger Spring, I must refer to the consideration of the more skilful. And if you please to give notice for a general Observation, what Springs do now most fayle, or more abound in any Vertue, Quality, or Quantity, it may probably be instructive for divers inferences; and particularly, it may give some degree of indication, Whether the Springs proceed from the fall of Rain, or by Subterraneous passages from the Seas, or by change of Air into Water.

But to returne to my Thermometer, I shall give you further notice, that on *Decemb.* 26. 1669. in the Morning, the Weather was colder than ever I found it, since I could take it by the measure of a Thermometer, that is, since these 5. or 6. years. It was very cold and frezing quick some dayes before, and ever since: And yet in this time the Mercury hath sometimes fallen more than an Inch, without any other change of Weather,

\* This was written before the great Snow fell. than some gusts of wind, some sprinklings of Snow \* at severall times, in all, scarce enough to cover the ground; and some abatements of Cold more especially when the Sun was up.

I have examined my *Almanac* from May 28. 1664. till now: In all which time I find it not remark'd for any such de-

gree of Cold, as hath been, since *Christmas* began, and continues every Night and Morning to this very day of *Decemb. 29*; though the extremest was, as hath been said, on *Decemb. 26*. To note this degree of Cold more particularly, I must acquaint you, that in my stanch Thermometer on the said 26 of *December*, the Liquor was at *three* inches and an *half*. This morning (*Decemb. 29.*) and one or two other mornings it was at *three* inches and *three quarters*. Most other times of these Cold days, Morning and Evening, it was at the height of *four* inches, in ordinary Brisk Frosts it is at *seven* inches. Yet here I must observe, that sometimes the Frost dissolves, when it is at the 7th figure, and sometimes I find it at the 8th figure in a smart frost: Whether the Winds, which come not to the Thermometer, may cause this difference, or what else, I know not. But to proceed, 'tis warm *May-weather*, when 'tis at the 10th figure, and 'tis not much above the 12th figure in the hottest weather of *June, July, and August*. To compare with former Winters, the lowest mark is upon *Decemb. 17. 1665*; and then it was at the height of *five* inches and an *half*. And in *Decemb. 31. 1666*, it was about the same height; and there I find these words; *Very cold, above all of this year, hitherto*. Neither do I find any note so low, till this present, which is considerably lower.

I think it remarkable, that the 7th Inch, and sometimes the 8th in my Thermometer should abide Freezing, and the Frost increase, till the Liquor descended  $4\frac{1}{2}$  inches; and yet, that it should not ascend from the 8th inch more, than  $4\frac{1}{2}$  inches in our hottest Summer, being hung in the same place within 18 inches of the Glass-window, facing the *North-west*, and in a little Writing-room, in the second row of Buildings. But now I am strongly perswaded, that the degrees of Heat and Cold are not exactly indicated by the inclosed *Spirit of Wine*: For, when the Snow melted, and the Frost was first dissolved without Sunshine, the Liquor was not above the height of *five* inches and an *half*. Possibly it retains some part of the Cold a while after the ambient Air becomes more tepid.

So farr Dr. Beale. What Dr. Wallis was pleased to impart on this Subject, was written January 7. 17<sup>66</sup>, at Oxford, as follows.

Concerning my Thermoscope and Baroscope (the former of which is known to give accompt of the Temper of the Air, as to *Heat* and *Cold*; the other, of its *Weight*;) I have some few particulars to add to the Observations, I sent you some years agoe.

The *first* is, that, whereas I did then observe, that in Hot weather the Quick-silver in the Baroscope did use to rise obserably, espec ally in Sun-shine and the Heat of the day; which might *seem* to argue the Air to be thereby made heavier, (which I find was the case of some other Baroscopes as well as of mine, and put us to some thoughts concerning the reason of it;) I do now find (having kept the same Barometer, for the space of five years, unalter'd,) the case, for these two years last past, to be somewhat otherwise: And that in hot Sun-shiny weather the Quick-silver doth rather subside a little; and in extreme Cold and Frosty weather it riseth.

Which maketh me Judge the Cause of these contrary Observations to be this, *viz.* That the Quick-silver, at its first putting into the Tube or Baroscope, was not so perfectly cleans'd from Air, but that some small quantity of it did remain, undiscern'd, in the Quick-silver: Which latent particles of Air, though so small as not to be at all discernable to the eye by bubbles, yet by the external heat (adding new strength, as it useth to do, to its Elastick or Springy power) were so much expanded as to give somewhat a greater bulk to the same quantity of Quick-silver, with which it was mingled, and consequently to make it rise somewhat higher, as being *specifically* lighter (that is, having the same weight in a larger dimension, or, in the same dimensions, a lesser weight;) and, upon the recess of the external heat, the Spring again slackening, the Air, being more compres'd, suffer'd the Quick-silver to be again contracted into its former lesser Dimensions, and so to become heavier, and not to rise so high as before, when it was hotter. But now, the Quick-silver

silver, having continued in the Tube for five years and upwards, hath by its own weight cleansed it self better from that little Air that was in it ; and that Air, freed from its entanglement with the Quick-silver, being got up into the void part of the Tube above the Quick-silver, doth act contrary-wise, that is, when it is by Heat (upon the strengthening of its Spring) expanded, it presseth down-ward upon the Quick-silver, and doth a little depress it ; and, on the contrary, when by Frost or very Cold weather this Air (by the abatement of its Spring) is contracted, the Quick-silver, freed from that pressure, riseth a little. But the Rising and Sinking on this account, (as well that formerly, when this Air was in the Quick-silver, as that now, when it is gotten above it,) is not very considerable ; hardly exceeding the twelfth part of an inch, or thereabout.

This Account I thought not amiss to give you, because it may possibly keep your self, or some others who make use of Baroscopes, from being impos'd upon by such Observations ; as if the Sun-shining or Heat of the weather did make the Air heavier than before ; whereas it seems to be but an *accidental* operation upon that un-observ'd Air latent in the Quick-silver. And I thought it the more necessary to take notice of it, because it is not so easily discover'd, unless by keeping the Baroscope unalter'd for a longer time, than (perhaps) is done by some of those, who make use of it ; and, without which, I had not discern'd it my self.

On this occasion, I shall add another Accident, which I lately took notice of. Observing in the late hard Frost, that the Quick-silver did not rise a little, at such time as, by reason of the fierce freezing, I expected it might ; I did suspect (as it prov'd to be,) that a little drop of water, (which was at first made use of for the cleansing of the Quick-silver from the Air, and which hath ever since remain'd on the top of the Quick-silver within the Tube,) was frozen fast to the glas, so as to stop the Quick-silver from ascending : And, to try, whether it were so or no, I did a little shake the Tube by moving it up and down, so as to make the Quick-silver undulate. Whereupon I found the frozen drop of Water to keep its place, while the undulating Quick-silver did several times beat against it. And,

(which is the thing, for which I mention it) the Noise upon these knocks was not such a dull noise, as Quick-silver or other Liquids use to make in the open Air, by dashing against Glass or Ice, or other such hard Bodies; but such a hard smart noise, as hard Metals use to make by knocking one against the other; or, as if this Ice had been so knock'd by a solid piece of Iron or other Metal of such a bigness. Which difference of noise from what would have been in the open Air (where the intermediate air must first have been beat away, before the Quick-silver could strike the Ice, and thereby the stroke of the liquid body obtunded or broken,) I attribute to that voidness of Air, which was between the Ice and the distant Quick-silver. And I remembred presently, that the Honourable Mr. Boyle had formerly shew'd me an Experiment, very like this, upon another occasion: which made me the readier to take notice of this; and I did it several dayes successively. But when, by applying the heat of a Candle to the side of the Glass, I had melted this Ice, I found (as I expected) that within a little time the Quick-silver was risen about a sixteenth part of an Inch above what it was before; which the freezing of the Water had till then hindred it from doing.

My Thermoscope, or Sealed Weather-glass, (which, having no communication with the Open Air, and so not being affected with its Weight, gives accompt but of its Heat and Cold;) hath, this last Frost, been much lower than I ever have known it, upon *five* years constant Observation. Which proceedeth partly from the Extremity of the Cold, more than ordinary; and partly from the inclosed Liquor (being Spirit of Wine, tinged with *Cochineal*,) growing less spirituous.

It was first made in *Decemb.* 1664. In the Months of *January*, and of *February* following, we had very smart frosts, more cold than ordinary; when yet the lowest mark, to which the liquor did subside (in very hard frosts, and very cold wind,) was at inches  $12\frac{1}{2}$ : (at which time,  $14\frac{1}{2}$  was frost certain, and sometimes at  $15$ : and at  $15\frac{1}{2}$ :) The high't in Summer following, 1665, was usually at  $20, 21, 22$ , or thereabouts; but in some few very hot dayes,

dayes, at 25, 26, 26 $\frac{1}{2}$ ; (the whole height of the smal Cylindr glass, whose cavity was about  $\frac{1}{8}$  of an inch diameter, being about 20. inches; besides a small Spherical bowl at the top, of about  $\frac{1}{4}$  of an inch diameter; and a bowl at the bottom, which contained the liquor, of about 2 inches diameter: the space above the liquor being, at the first composure of it, voyd of Air, save what it had out of the liquor, which, being warm at the first putting in, fill'd the whole cavity, while the Glas was hermetically sealed.)

The Winter following, the liquor seem'd to remain much about the same temper as in the next foregoing. For in *December*, *January*, and *February*, we had at 14 $\frac{1}{2}$  Frost certain; sometimes at 15. or higher; and the lowest, to which it did that winter descend, was 12 $\frac{1}{2}$ . The height, in the following Summer, 1666. was usually about 19, 20, 21; the highest of all, at 25.

About the end of *December* 1666, and the beginning of *January* following, it was, in hard frosty weather, at 12, 11, and once at 10 $\frac{1}{2}$ , the weather being very cold, and the liquor (it should seem) becoming some-what less spirituous, having evaporated some of its more subtil parts into the voyd cavity: and it was Frost certain, that winter, about 13 $\frac{1}{2}$ , (an inch lower than the years before;) sometimes at 14, or 14 $\frac{1}{2}$ . The usual height in Summer following, 1667, was about 19, 20, 21, and the highest at 24 $\frac{1}{2}$ .

The Winter following; it was scarce certain frost at 13; but yet sometimes at 14, or a little higher: the lowest, to which it did descend that winter, (being very mild after Christ-mass,) was at 12. And the following Summer, 1668, usually about 18, 19, 20; the highest of all (the heat of that Summer being but very moderate,) at 22.

The next Winter it was frost certain, abour 12 $\frac{1}{2}$ ; but sometimes, at 13. or higher: the lowest of all, at 10 $\frac{1}{2}$ . And in the Summer following, 1669, the highest of all (being but a cool Summer) not much above 20.

But now this Christmas, 1669, though I find it to be frost certain, about 12 $\frac{1}{2}$ , and sometimes at higher than 13; yet hath it come some-times lower than 8; and particularly *Decemb<sub>r</sub>*. 26

in the morning, to  $7\frac{1}{4}$ , and did not all that day come so high as 8. inche<sup>s</sup>. Which being so much lower, than ever it had been in any of the precedent years of my obsevation, though it may in part be attributed to the dis-spiriting of the liquor, yet principally to the extremity of the Cold.

It hath ever since been rising, (but with some descent in the night-time,) and was on *January 1*, when the frost seem'd first to relent, somewhat higher than  $9\frac{1}{2}$ ; and is this day, *Januar. 7*, about  $13\frac{1}{2}$ . The Baroscope at  $29\frac{1}{2}$ ; but for some days before, it was about  $28\frac{1}{4}$ , (the weather having been windy and rainy;) and so it was in the frost, about *Decemb. 25*, but then continued to rise till about *Januar. 2*, to  $29\frac{1}{2}$ ; but had been *Decemb. 13*, at  $30\frac{1}{4}$ ; which is the highest, I have ever known it in my Baroscope;  $27\frac{1}{2}$  being the lowest, that I have ever observed it in, (*Octob. 26. 1665*;) the most usual hight being about  $29$ , or somewhat higher.

But, though mine have been very rarely, and but very little, above  $30$ , or lower than  $28$ , (reckoning from the surface of the stagnant Quicksilver;) Yet in other places (according to the difference of Airs) it may by others have been found either higher or lower: and so likewise, according as the Quick-silver, at the first filling of the inverted Tube, was more or less cleansed of Air. For, a very little Air, left in the Quick-silver, and un-discernable to the Eye, will, when it gets free of it, and remains in the voyd space above the Quick-silver, sensibly depress the Quick-silver: And in the mean time, (before it so gets free) will, upon heat of weather, make it swell.